CHAPTER TWO

NEGLECTED DISEASES: CONTRIBUTIONS FROM CONTINENTAL MALACOLOGY

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Neglected tropical diseases (NTDs), many of them parasitic, are prevalent in the poor populations (with low or medium-low income) of rural areas and suburban neighborhoods, who have little access to health services. NTDs affect more than 100 million people worldwide, and children are the most vulnerable group (World Health Organization 2010). These diseases can cause permanent disability and even death. Poor water management, bad housing and poor sanitation conditions are all factors that increase the likelihood of NTD transmission. Of the 17 NTDs listed by the World Health Organization (WHO 2013), three are parasitic zoonoses that use snails as intermediary hosts; foodborne trematode infections (fascioliasis and others), schistosomiasis (bilharziasis) and soil-transmitted helminthiasis (angiostrongyliasis and others). As part of a

global plan to combat NTDs, the WHO recommends five strategies: (i) preventive chemotherapy; (ii) intensified case-management; (iii) vector control; (iv) provision of safe water, sanitation and hygiene and (v) public veterinary health. With regard to the first of these, thanks to pressure from the Union of South American Nations (UNASUR, which includes Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Surinam, Uruguay and Venezuela), in 2012, the 65th World Assembly of Health began promoting a process of increasing the investigation and production of medicines for NTDs, which has stimulated the debate on multilateral mechanisms for ensuring the access of poor populations to fundamental medicaments (South American Institute of Government in Health 2012).

Besides the already mentioned strategies, other comprehensive actions are required, such as preventative education (which reduces prevalence) and the improvement of access to water and sanitation services (e.g. wastewater and waste disposal). Schistosomiasis, fascioliasis and other helminthiases have increased the focus on infection, and due to their association with other diseases, parasites can be said to cause 50% of deaths amongst the world's immunodeficient population (Combes 1990).

Regional view: Snails as Intermediate Hosts of NTDs

Able to cross boundaries throughout South America, continental mollusks are intermediate hosts (IH) of parasites affecting humans, production animals and pets. However, a lack of trustworthy statistics hampers efforts to extrapolate the real incidence rates of NTDs. The development and ongoing updating of databases is essential for establishing monitoring programs, identifying species groups of biomedical importance, adding to current knowledge of biodiversity, assessing the status of regional fauna in terms of habitats, endangered species etc, and detecting the introduction of exotic and invasive species.

One of the most important pathways of disease spreading in austral South America is located in the Northeastern Region of Argentina (NEA). This region contains areas of high diversity, rich in mollusk species.

SCHISTOSOMIASIS: according to WHO, schistosomiasis affects at least 207 million people worldwide, and more than 70 million of them live in endemic areas. The disease is frequent in tropical and subtropical regions, particularly in poor communities. In America it is caused by *Schistosoma mansoni* (Sambon 1907) (Digenea) which is transmitted by snails of the family Planorbidae; *Biomphalaria glabrata* (Say 1818), *Biomphalaria tenagophila* (d'Orbigny 1835) and *Biomphalaria straminea* (Dunker

1848). Four other species have been experimentally infected; *Biomphalaria peregrina* (d'Orbigny 1835), *Biomphalaria amazonica* (Paraense 1966), *Biomphalaria orbignyi* (Paraense 1975) and *Biomphalaria oligoza* (Paraense 1974). In contrast, *Biomphalaria occidentalis* (Paraense 1981), *Biomphalaria intermedia* (Paraense and Deslandes 1962) and *Biomphalaria schrammi* (Crosse 1864) are resistant to infection. The *Biomphalaria* species are widely distributed across Neotropical America, reaching up to the north of Argentinean Patagonia.

Schistosomiasis occurs today in Brazil, Venezuela, Surinam, Puerto Rico, the Dominican Republic and several islands of the Lesser Antilles, with evidence of having spread southward from northeastern Brazil. Because of its introduction into territories of the South American Caribbean, an expansion of the current disease distribution area can be expected, since the range of mollusk species that can act as IH is wider than that of the disease (Organización Panamericana de la Salud 2003).

At present, the southernmost areas of South America in which schistosomiasis has been recorded include the Brazilian localities of São Francisco do Sul (Santa Catarina State) at the head of the Iguazú River, where its IH is *B. tenagophila*; the Rio Grande do Sul State with *B. glabrata* as IH; and the Piquiri River Basin, flowing out to the High Paraná River, in this case transmitted by *B. glabrata* (Bernardini and Machado 1981).

In Argentina, the area at the highest risk of the establishment of an endemic focus is located in the NEA Region, where the majority of the *Biomphalaria* species inhabit the most important rivers of the Del Plata Basin. Five species are listed as potential IH of schistosomiasis: *B. tenagophila, B. straminea, B. peregrina, B. orbignyi* and *B. oligoza*. These species show a wide distribution, populating a diverse range of environments while preferring those of shallow, temporary water (Rumi 1991, Rumi *et al.* 1997).

FASCIOLIASIS: with a cosmopolitan distribution, this disease is caused by *Fasciola hepatica* (Linnaeus 1758) (Digenea) and is considered one of the most important parasites to affect cattle, causing great economic losses. It can occasionally infest humans through the consumption of vegetables (usually wild and found growing near water) or contaminated water (Combes 1990).

Fasciola hepatica has an extensive range in Argentina, from the extreme north to central Patagonia, and from the Andean Cordillera to the Atlantic coast. It predominantly occurs in the lowlands of the province of Buenos Aires, the region of the Paraná River, including the provinces of

Entre Rios and Corrientes (Boero 1967) and also the provinces of Neuquén and Chubut (Johnstone 1971).

The epidemiology of *F. hepatica*, like that of other zoonotic agents, shows regional differences. The study of its transmission cycle, therefore, requires local attention in order to establish measures for its prevention and control. In America, the following Lymnaeidae species have been cited as IH: *Lymnaea truncatula* (Müller 1774), *L. humilis* (Say 1822), *L. bulimoides* (Lea 1841), *L. cubensis* (Pfeiffer 1839), *L. viator* or *L. viatrix* (d'Orbigny 1835), *L. diaphana* (King, 1830) and *L. columella* or *Pseudosuccinea columella* (Say 1817). *Physa cubensis* (Pfeiffer 1839) (Physidae) was also cited as an IH (Paraense 1982). In Argentina, *L. viator* and *L. columella* have been reported to be IH (Cucher *et al.* 2006).

PARAMPHISTOMOSIS: is a parasitosis produced by several genera of trematodes found in domestic and wild ruminants. It is distributed all around the world, with reports of clinical and subclinical losses and mortality of infected cattle in countries with high prevalence. The disease has been reported in deer, bison and other wild ruminants, but is more frequent among production animals (bovines, caprines and sheeps) (Sanabria 2011).

Some years ago, veterinarians expressed alarm because new adult specimens were found in rumen in the field, causing diarrhea. Ignorance of the parasite's life cycle, pathogeny and therapeutic options at a local level has often led to mistakes in clinical diagnosis and the use of empirically proven treatments for *F. hepatica*, expecting and not getting similar results (Sanabria 2011).

In North America, paramphistomes have been recorded in *Lymnaea palustris* (Müller 1774), *L. cubensis* and *L. humilis*. In the Southern Hemisphere, *L. columella* was identified as one of the IH. In Brazil, other IH include the planorbid snails *B. tenagophila*, *B. peregrina* and *Drepanotrema kermatoides* (d'Orbigny 1835). In Uruguay, the presence of cercariae of Paramphistomidae was also detected in *Drepanotrema anatinum* (d'Orbigny 1835) (Sanabria and Romero 2008).

In Argentina, the parasites *Cotylophoron cotylophorum* (Fischoeder 1901) and *Balanorchis anastrophus* (Fischoeder 1901) were found to be responsible for disease. The former has a wider distribution over the territory, while the latter is restricted to northeast of the country. Several species of the families Planorbidae and Lymnaeidae are believed to act as their IH. Additionally, cercariae of *Paramphistomum sp.* were found in *Drepanotrema depressissimum* (Moricand 1839) and also identified in the

rumen of confirmed hosts (cows and sheep) (Schiffo and Lombardero 1974, Raccioppi *et al.* 1995, Sánchez *et al.* 2005).

ALIEN SPECIES: the introduction of exotic species of gastropods is relevant because they could act as IH for local parasites and might also contribute to the spread of exotic parasites. As an example, the introduction of the Giant African Land Snail, *Achatina fulica*, (Bowdich 1822) to Brazil led to serious concerns about its role as a vector for human angiostrongyliasis, which is parasitosis caused by the native *Angiostrongylus costaricensis* (Morera and Cespedes 1971) and the exotic *A. cantonensis* (Chen 1935) (Thiengo *et al.* 2010). Although parasitological studies of terrestrial gastropods (slugs and snails) in Brazil have been taking place since the late 20th century, in Argentina, the sanitation levels of almost all terrestrial gastropods are still unknown.

Databases and projection of malacological studies in Argentina

The numerous field and laboratory works conducted over the last three decades have allowed us to collate a database of Argentinean continental mollusks that includes more than 5000 entries. These records come from the collections housed in Argentina's most distinguished museums (Museo de La Plata, Museo Argentino de Ciencias Naturales and Instituto Fundación Miguel Lillo, among others). This database has allowed us to cross reference information from different studies with very different objectives (e.g. distributional, parasitological, populational, taxonomical etc.) In recent years, we have also started to incorporate genetic and historical information.

Taking a regional approach, a study of the species richness and diversity patterns of freshwater gastropods of Argentine Mesopotamia was performed (Rumi *et al.* 2004). Later, from an analysis of the entire Argentine territory, 101 continental aquatic gastropod species were listed (Rumi *et al.* 2006), from 10 families: Ampullariidae (12 spp.), Cochliopidae (16 spp.), Lithoglyphidae (22 spp.), Thiaridae (4 spp.), Ancylidae (5 spp.), Chilinidae (16 spp.), Glacidorbidae (1 sp.), Lymnaeidae (5 spp.), Physidae (5 spp.) and Planorbidae (15 spp.). This work also distinguished between endemic species (40, only present in Argentina), vulnerable species (45 spp.) and exotic species (4 spp.)

The above information was then supplemented by updating the list to include freshwater bivalves occurring in Argentina (Rumi *et al.* 2008). Of these, 65 species from seven families were recognized: Hyriidae (13

species), Etheriidae (18 spp.), Sphaeriidae (25 spp.), Corbiculidae (4 spp.), Mytilidae (3 spp.), Solecurtidae (1 sp.), and Erodonidae (1 sp.). Of these, at least 13 species are considered endemic (most of which are in the family Sphaeriidae), and three are exotic.

In order to identify and characterize regions of freshwater gastropods on the basis of their distribution, diversity, richness and biological value, a similarity analysis among basins was then performed. As a result of this study, eight freshwater gastropod provinces were identified: I, Misionerean; II, Middle Paraná; III, Uruguay River; IV, Lower Paraná - Río de la Plata; V, Central; VI, Cuyo; VII, Northern Patagonia; and VIII, Southern Patagonia. These malacological provinces are similar, in general, to the ichthyological regions already identified (Núñez *et al.* 2010).

Taxonomic studies of continental freshwater gastropods in Argentina include doctoral theses on three families of importance to health, and works on other families capable of playing IH to parasites of ruminants. Through these works the family Planorbidae has been revised. This group includes 15 species in four genera: *Acrorbis*, *Antillorbis*, *Drepanotrema* and *Biomphalaria* (1, 1, 6 and 7 species respectively). Some of the *Biomphalaria* species found are IH of *Schistoma mansoni* in other countries (Rumi 1991), while others are potential hosts. The taxonomy of the species of the family Chilinidae (of which at least 17 can be found in Argentina) occurring in the La Plata Basin has been revised; a new species was described, and four others were redescribed (Gutiérrez Gregoric and Rumi 2008, Gutiérrez Gregoric 2010, Gutiérrez Gregoric *et al.* 2014). As regards the family Physidae, a review of the five species occurring in Argentina was conducted which included comparative anatomical and ecological studies of the two predominant species, one of which is exotic and is currently spreading (Núñez 2010, 2011).

Our understanding of the status of regions' molluscan fauna (e.g. habitats, endangered, exotic and invasive species), has been increased by conducting numerous samplings, which have resulted in the identification and description of several new species of terrestrial and aquatic gastropods (e.g. Fernández and Rumi 1980, 1984, Bonetto *et al.* 1983, 1986, Landoni *et al.* 1999). Sampling has also permitted us to refine the known distribution of many species, such as the native *Megalobulimus sanctipauli* (Ihering and Pilsbry 1900) (Beltramino 2013) and the invasive gastropods *Melanoides tuberculata* (Müller 1774) (Gutiérrez Gregoric *et al.* 2007, Gutiérrez Gregoric and Vogler 2010, Peso *et al.* 2011) and *Achatina fulica* (Gutiérrez Gregoric *et al.* 2011, 2013, Vogler *et al.* 2013).

From the taxonomic and geographic information compiled, we have begun to sort and enhance knowledge about continental freshwater

mollusk species in Argentina according by type and by degree of contribution to local and regional biodiversity. For terrestrial gastropods, however, the georeferenced database is still in development; in spite of this, 21 terrestrial exotic species have been identified (Rumi *et al.* 2010).

As previously mentioned, the NEA Region is part of the Del Plata Basin and includes the environments and species of the northern tropical areas. Many of these taxa have their southernmost distribution within the NEA, and are potential vectors of human parasites, zoonoses and endemic diseases. A surveillance mechanism that allows the monitoring of occurrence areas in order to understand and identify possible infection sources is therefore necessary. We must also consider the degree of susceptibility of different species and their parasitic strains to them, since many of them may differ according to locality. First and foremost, special attention should be paid to those freshwater species involved in the transmission of schistosomiasis, fascioliasis and paramphistomosis. Furthermore, efforts should also be directed toward the early detection and monitoring of newly introduced species (aquatic and terrestrial) that could potentially act as vectors. In Argentina, this line of research is being developed through the continuing efforts of all the malacologists at the Division Zoología de Invertebrados of the Museo de La Plata, and by ongoing contact and exchange of information with other research groups in Argentina and Latin America.

We emphasize the need to keep the databases updated with the latest information (biological and bibliographical) in order for them to continue constituting useful reference tools. Efforts should also be made to train new young researchers. Furthermore, we consider it is necessary to propose discussions on topics that allow the generation of our own regional and local indicators to reflect the advances of the discipline, taking into account the environmental and social diversity of our countries.

Finally, it is essential to generate regional strategies that allow the optimization of environmental education and diffusion of information, taking into account that most local scientific results are not accessable through the international system.

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